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Pulling at Your Heartstrings:

Examining Four Leadership Approaches from the Neuroscience Perspective

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Abstract

Purpose: This review study aims to bridge neuroscience and educational leadership by exploring the neural mechanisms of the constructs relevant to educational leadership.

Research methods: The reviewed literature includes 69 neuroscience studies and four books on neuroscience. The brain activities and neurotransmitters associated with the constructs pertinent to educational leadership were coded to bridge the knowledge base of neuroscience and educational leadership.

Findings: The neural mechanisms of the constructs related to educational leadership (e.g., vision, charisma, trust, and organizational justice) were organized by four different leadership approaches: charismatic, transformational, destructive, and culturally responsive school leadership. Emotions are the common thread weaving through all four leadership approaches.

Implications: This study has salient theoretical, methodological, and practical implications for educational leadership. Theoretically, the findings not only accentuate the role of emotions in educational leadership, but also reveal the trade-off between emotions and analytical calculation in leaders' decision making. Methodologically, the neuroscience methods (e.g., fMRI, qEEG, and hormonal analysis) add to the methodological repertoire of educational leadership research. Practically, the findings warrant the emotion training and present the potential of using neurological measurements in school leadership preparation and professional development.

Keywords: charismatic leadership, culturally responsive school leadership, destructive leadership, emotions, neuroscience, transformational leadership

Pulling at Your Heartstrings:

Examining Four Leadership Approaches from the Neuroscience Perspective

This study aims to bridge neuroscience and educational leadership by exploring the neural mechanisms of the constructs relevant to educational leadership. The theoretical groundings of educational leadership are largely undergirded by the constructs from psychology, sociology, socio-psychology, administrative science, and economics (Bates, 1980; Wang, 2018). Recently, these neighboring fields have been advanced by neuroscience that probes into the neural mechanisms of psychological processes, social interactions, organizational behaviors, and decision making; thus, many neuroscience subfields have emerged, including cognitive neuroscience, social neuroscience, organizational neuroscience, and neuroeconomics. What neuroscience insights have been offered to the field of educational leadership? This review study seeks to answer this question by connecting the core constructs relevant to educational leadership and their neural mechanisms uncovered in neuroscience, in particular the aforementioned neuroscience subfields closely related to educational leadership.

This study is guided by Hallinger's (2014) conceptual framework for systematic literature reviews. In the framework, Hallinger specified five questions that need to be addressed in a systematic review, including the central topic of interest, conceptual perspectives, data sources, data analysis, and major results. Guided by Hallinger's framework, this review—with the central interest in exploring the neural mechanisms of the core constructs pertinent to educational leadership—begins with building the connections between the core constructs undergirding the theoretical groundings of educational leadership (Wang, 2018) and the findings of those constructs in neuroscience.

Since neuroscience is fairly new to the field of educational leadership, I provide a brief tour of the human brain, before describing how the literature data were collected and coded in this study. I then delineate the findings on the neural mechanisms of the core constructs in educational leadership by organizing them under four educational leadership approaches (charismatic, transformational, destructive, and culturally responsive school leadership). Grounded in the findings, I conclude with a discussion on the theoretical, methodological, and practical implications of applying neuroscience to educational leadership.

Educational leadership and Neuroscience

The theoretical groundings of educational leadership have been undergirded by the constructs falling into four categories over the last decade: leadership approaches, organizational theory, social- and psychological-themed constructs, and social justice-themed constructs (Oplatka, 2009, 2010; Wang, 2018). First, educational leadership is conceptualized from different but overlapped approaches: distributed leadership, instructional leadership, transformational leadership, and teacher leadership. Second, organizational theory, along with the related theories and constructs such as institutional theory, organizational learning, organizational culture and climate, and organizational citizenship behavior, serve as one of the conceptual underpinnings of educational leadership research. Third, the social- and psychological-themed constructs that are frequently used to conceptualize educational leadership research include trust, motivation, self-efficacy, collective efficacy, social capital, and social network theory. Fourth, the social justice-themed theories and constructs—such as critical race theory and social justice leadership—are also part of the conceptual groundings of educational leadership research.

What does educational leadership have to do with neuroscience? The interdisciplinary field of educational leadership frequently draws upon knowledge from psychology, sociology, socio-psychology, administrative science, and economics (Bates, 1980), as manifested by the theoretical groundings summarized above. Despite the interdisciplinary nature, there has been scant effort in applying natural science to educational leadership. Yet Evers and Lakomski (2015) explicated the linkage between natural science, particularly cognitive neuroscience, and educational leadership, stating that “one of the advantages of working out an epistemological accommodation between a social science such as administration and natural science, is that we can help ourselves to the best natural science for understanding social phenomena” (p. 416). They considered administrative theory as cohering with natural science, which could be potentially applied to enrich administrative theory. Drawing on natural science, Lakomski (2016) posited that educational leaders’ decision making has a neural basis—the brain functions that not only vary among individual leaders, but also are socially situated in organizational contexts. Further, over the decision-making process, there is no rationality-emotion dichotomy (Lakomski & Evers, 2010, 2012). The rational and emotional parts of the brain are sometimes localized in the same brain regions (Damasio, 1994). For instance, the ventromedial prefrontal cortex/orbitofrontal cortex (vmPFC/OFC) is the brain region above our eye sockets, active when we feel the emotions of empathy, guilt, and regret. If emotions simply disrupt our decision making, then shutting down this emotional part of our brain and tuning out emotions would help us make optimal decisions. But that is far from the case. People with brain damage in the vmPFC make cold-hearted, emotionally-detached, highly utilitarian decisions to maximize the greater good, such as being willing to sacrifice one family member to save five strangers (Thomas, Croft, & Tranel, 2011). They also make poor decisions, including making myopic decisions that seek immediate gratification rather than waiting for a larger reward delivered later, have impaired abilities to consider the future consequences of decisions, lack self-control (e.g., alcohol and drug abuse), and have diminished empathy, guilt, and regret (Bechara et al., 1999). Moreover, given the function of the vmPFC in calculating the risk and uncertainty in decision making, it is no surprise that low activation in the vmPFC is associated with trust—a core educational leadership construct that has a dimension of willingness to risk vulnerability (Dimoka, 2010; Tschannen-Moran & Hoy, 2000; Wang, 2018). Intriguingly, the feeling of power (i.e., having control over the behavior and circumstances of others through reward- and punishment-related resources; Fiske, 1993) changes how human brains respond to others emotionally in a way that is similar to the patients having the brain damage in the vmPFC (Keltner, 2017). This might explain why once people assume positions of power, they tend to have decreased trust in social interactions, have diminished empathy, as well as being aggressive, coercive, impulsive, and deceptive (Hogeveen, Inzlicht, & Obhi, 2014; Schilke, Reimann, & Cook, 2015; van Kleef et al., 2008). Taken in conjunction, considering the intertwined neural mechanisms between rationality and emotions, Lakomski and Evers (2012) described the role of emotions in decision making as “passionate rationalism” (p. 438). To that end, neuroscience is revealing to educational leadership in the sense that educational leadership is a social process, and the human brain is a social organ interacting with other brains in social contexts (Gazzaniga, Ivry, & Mangun, 2013). Accordingly, neuroscience can offer much insight to educational leadership, and “we ignore such knowledge at our peril” (Lakomski & Evers, 2017, p. 58).

Neuroscience is the study of the development and functions of the nervous systems. In humans, neuroscience focuses on the neural processes, along with cellular, hormonal, and genetic processes, which support the body and the mind (Bears, Connors, & Paradiso, 2016). Given the close interplay between the knowledge in organizational science and educational leadership (Oplatka, 2014), a subfield closely related to educational leadership is organizational neuroscience which seeks “to understand and incorporate the cognitive machinery behind our thoughts and actions into organizational theory” (Becker, Cropanzano, & Sanfey, 2011, p. 934). As using neuroscience to study organizational behavior is fairly new, scholars have explored different terms to describe this fledgling field. To underscore the cognitive process, the term “organizational cognitive neuroscience” was proposed (Lee, Senior, & Butler, 2012). Organizational (cognitive) neuroscience is interested in not only the brain’s biological systems (the neural, hormonal, and genetic mechanisms), but also how the biological systems, psychological processes, and social stimuli interact with one another, and thus shape human behavior in organizational contexts (Lee et al., 2012). For instance, at the hormonal level, dopamine is associated with motivation and obtaining a leadership position (Li, Wang, Arvey, Soong, Saw, & Song, 2015). At the genetic level, the dopamine receptor gene DRD4 VNTR was found to be associated with job satisfaction, mediated by job pay (Song, Li, & Arvey, 2011). As De Neve et al. (2013) noted, “genes—and the neurological processes that they influence—are upstream from personality factors related to the emergence of leadership” (p. 46). Thanks to the appreciable effect of genetics on leadership, Bass and Bass (2008) stated, “the genetic factor needs to be taken into account in any complete examination of leadership” (p. 1203). It is particularly important to emphasize from the outset that genetics *alone* do not determine leadership behaviors; it is the *interactions* between genetics and environments (e.g., a leader’s childhood, upbringings, past professional experiences, leadership training, and being mentored) that drive leadership behaviors (Zhang, Ilies, & Arvey, 2009). Or, put another way, leadership behaviors depend on both leaders’ individual disposition and the environment in which they find themselves.

In the field of educational leadership, Sergiovanni (1992) considered leadership behaviors as the overt manifestation of the leaders’ decision making, and are at the end of a chain of “heart (what the leader value and believe), head (the leaders’ mindscapes of how the world works), and hand (the decision, action, and behaviors of leadership)” (p. 308). Hence, to fully understand educational leadership behaviors (the “hand” in Sergiovanni’s analogy), it is helpful to understand the metaphorical “heart” and “head”, both of which reside in the leaders’ brain. It is the leaders’ brain that enables their decision making and the resultant leadership behaviors in an organizational context where the leaders, followers, and social context converge (Burke, 1965). Building on prior work of applying neuroscience to probe the role of emotions in educational leaders’ decision making (Evers & Lakomski, 2015; Lakomski, 2016; Lakomski & Evers, 2010, 2012, 2017), this study draws upon neuroscience to connect the leaders’ heart, head, and hand through the unifying organ: the leaders’ brain. Before proceeding, to understand the neural mechanisms of the core constructs in educational leadership, it is necessary to embark on a brief tour of our brain.

A Brief Tour of Our Brain

Our brain, as an essential social organ of the human nervous system, is remarkably complex. Billions of neurons (i.e., brain cells) are the basic units that receive, evaluate, and transmit information through synapses. At the synapses, many neurons communicate with one another through the chemicals called neurotransmitters. Among over 100 neurotransmitters in human brains, a handful of them are closely related to the constructs in educational leadership: oxytocin is associated with trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005); dopamine is associated with motivation and obtaining a leadership position (Li et al., 2015). The variance in the volume of these neurotransmitters influences the communications among neurons in certain brain regions (i.e., a set of neurons), thereby affecting human behavior in organizational contexts. Below I highlight a few brain regions and brain systems (i.e., a network of brain regions) that support particularly important brain functions relevant to educational leadership.

The prefrontal cortex.

The prefrontal cortex (PFC, Figure S1), located at the front of the brain, supports both cognition and emotions in decision making (Gazzaniga et al., 2013). Two regions in PFC are particularly important to some constructs in educational leadership: the dorsolateral PFC (dlPFC) and ventromedial PFC (vmPFC). First, the dlPFC supports cognition and self-control. For example, the dlPFC is active when people regulate their own racial bias (Knutson, Mah, Manly, & Grafman, 2006). Second, the vmPFC is associated with emotions in decision making and social cognition (i.e., the cognitive process in social interactions; Gazzaniga et al., 2013). The volume of the vmPFC predicts how well a person understands others' mental states (i.e., mentalizing) and how big a person's social network is (Lewis, Rezaie, Brown, Roberts, & Dunbar, 2011). Moreover, the vmPFC is part of the brain's default-mode network (DMN; Buckner, Andrews-Hanna, & Schacter, 2008). The DMN is a network of brain regions that are active when we perform the tasks intersecting emotions and social interactions, such as making moral decisions (Pascual, Rodrigues, & Gallardo-Pujol, 2013).

The importance of the DMN in educational leadership lies in its *antagonistic* relationship with another brain network called the task-positive network (TPN; Bagozzi et al., 2013). The TPN is activated when we perform the tasks that demand logical reasoning and dehumanizing (i.e., the denial of humanness such as viewing humans as objects by assigning economic values to individuals; Jack, Dawson, & Norr, 2013). The DMN-TPN antagonistic relationship is analogous to the "two ends of a seesaw" (Lieberman, 2013, p. 27): when the TPN is activated, the DMN is suppressed, and vice versa. This DMN-TPN trade-off suggests the neural constraints for educational leaders who cannot be "both genuinely empathetic and analytic at the same time" (Boyatzis, Rochford, & Jack, 2014, p. 6), or cannot stay focused and being receptive to new ideas at the same time (Jack et al., 2013). To that end, an overemphasis on leaders being analytical and solving problems, which activates the TPN and suppresses the DMN, may lead to the lack of empathic and moral concerns for others, as well as resisting new ideas; whereas an overemphasis on leaders focusing on people and emotions, which activates the DMN and suppresses the TPN, may lead to the loss of focus on accomplishing clearly defined goals (Boyatzis et al., 2014).

The dopaminergic system.

The dopaminergic system (Figure S2) is the brain's reward system, supporting people's pleasure-seeking behaviors. When the dopaminergic system is activated by stimuli, we feel hedonic pleasure as a reward, thereby driving our reward-motivated decision making and the resultant behaviors to seek even more pleasure. The dopaminergic system is activated by a variety of stimuli, including eating comfort food (Demos, Kelley, & Heatherton, 2011), and being altruistic such as carrying out altruistic punishments (i.e., punishing those who violate social norms, even when carrying out the punishment would incur cost on our end; de Quervain et al., 2004). The dopaminergic system is also activated when we are treated fairly (Tabibnia, Satpute, & Lieberman, 2008), in particular the same brain regions that are activated when we eat chocolate; thus, both figuratively and literally, "fairness tastes like chocolate" (Lieberman, 2013, p. 73). Our altruistic behaviors and innate desire for fairness have their neural roots in the dopaminergic system, suggesting that we derive pleasure from being altruistic and being treated fairly. Given its role in motivation (a core construct in educational leadership; Wang, 2018) and the resultant reward-motivated behaviors, the dopaminergic system renders itself essential in leadership regarding how leaders motivate themselves and others (Bass & Bass, 2008).

The limbic system.

The limbic system (Figure S3) is the emotional brain, as its main function is to process emotions. It recruits a complex network of brain regions, including the cingulate cortex, hypothalamus, and amygdala (Gazzaniga et al., 2013). The cingulate cortex is activated when we feel emotional pain caused by being excluded and marginalized in social interactions (Eisenberger, 2012). The hypothalamus is the main site for producing and regulating hormones, such as oxytocin associated with trust and empathy (Barraza & Zak, 2009; Kosfeld et al., 2005), and testosterone related to social dominance and gaining power (Sellers, Mehl, & Josephs, 2007). In the limbic system, another brain region closely related to educational leadership is the amygdala, which contains receptors for many neurotransmitters such as dopamine, serotonin, and oxytocin, as well as processes and regulates emotions, particularly the negative ones such as fear and anxiety (LeDoux, 1998). The role of the amygdala in educational leadership is further detailed in the Results section.

Taken together, the brain regions are connected both structurally and functionally (Park & Friston, 2013). One brain region (e.g., the amygdala), which is connected neuroanatomically to multiple brain regions, supports multiple brain functions; one brain function (e.g., empathizing with others) engages multiple brain regions (Gazzaniga et al., 2013). The brain, with all the systems working together as a whole, drives human behaviors in social contexts such as organizations. As it will be seen, many constructs pertinent to educational leadership are supported not by one brain region, but by the interconnected brain systems in an intriguingly complex manner. Notably, applying neuroscience to educational leadership is *not* to take a reductionist approach: seeking to reduce socially situated leadership behaviors to the activity or inactivity in XYZ brain regions, neurons, or even genes when a given leadership behavior occurs, because there are no unique neural substrates of an educational leadership behavior (Ashkanasy, Becker, & Waldman, 2014). Rather, an appropriate approach is to view the neural basis of leadership behaviors as multiple brain regions in both leaders' and followers' brains working in unison (Cacioppo, Berntson, & Nusbaum, 2008). At the individual leader level, many of leaders' brain functions (e.g., cognition, emotion, attention, and memory) are rarely localized to one particular brain region, but engage a highly distributed process that recruits multiple brain regions. More importantly, these multiple brain regions sometimes work together to generate a behavioral response (e.g., the overlapped neural mechanisms between empathy and moral decision making; Moll, Zahn, de Oliveira-Souza, Krueger, & Grafman, 2005; Pascual et al., 2013); other times these multiple brain regions work antagonistically (e.g., being empathic and being analytic in decision making; Boyatzis et al., 2014). At the team level, leaders emerge from the brain-to-brain synchronization between the leaders and followers (Jiang et al., 2017). This leader-follower brain activity resonance seems like both the leaders and followers being on the same "brainwaves", attesting to the saying "we are on the same page" (Boyatzis et al., 2012). In line with this socially situated view, instead of viewing a leader's brain as the sole cause of leadership behaviors, an appropriate approach is to examine how the leader's brain function is influenced by both leaders' individual differences in disposition and organizational socialization context in which both educational leaders and their followers participate. The neural mechanisms synthesized in this study, to a large extent, are the parsimonious version of how our brain works in organizational contexts. Nevertheless, to connect neuroscience and educational leadership approaches, here I proceed to uncover the neural mechanisms of the core constructs underpinning educational leadership.

Method

Searching the Literature

Given the expansive body of neuroscience literature, it is important to clarify the boundaries of literature search for this study. Two inclusion criteria are thus set: (1) the neuroscience studies investigating the core constructs germane to educational leadership (e.g., vision, trust, motivation, and justice; Oplatka, 2009, 2010; Wang, 2018); and (2) the neuroscience studies investigating the under-studied constructs germane to educational leadership but are frequently studied in the broad field of administrative science (e.g., charisma and personality traits; Meuser et al., 2016).

This study began with 40 empirical articles examined in the most recent review of organizational neuroscience (Butler, O'Broin, Lee, & Senior, 2016). This is because no empirical studies were found that intersected educational leadership and neuroscience. Given the fact that educational leadership is closely related to administrative science (Oplatka, 2014), it is sensible to look into these neighboring fields which have already ventured into the field that intersects neuroscience and administrative science. To further explore the neural mechanisms of the constructs undergirding educational leadership, the references of the 40 articles were also examined for this study.

Another source of literature is the recent book *Monographs in Leadership and Management: Organizational Neuroscience* (Waldman & Balthazard, 2015). Moreover, to capture the comprehensive neuroscience literature, this study also included the recent edition of three books: Bear et al.’s (2016) *Neuroscience: Exploring the Brain*, Gazzaniga et al.’s (2013) *Cognitive Neuroscience: The Biology of the Mind*, and Glimcher and

Fehr's (2014) *Neuroeconomics: Decision Making and the Brain*. Taken together, 69 empirical neuroscience studies and four books were reviewed for this study.

Data Extraction and Analysis

An extraction dataset was compiled for this study, in which each reviewed article had an entry. For each article, I extracted the descriptive information of each article, including article title, goals of study, research design, constructs under investigation, variable measures, and findings. To bridge the knowledge base of neuroscience and educational leadership, two tables were created to summarize the brain regions (see Table S1), as well as the neurotransmitters and hormones (see Table S2) associated with the constructs pertinent to educational leadership.

Results

Although many constructs (e.g., charisma, vision, and organizational justice) do not explicitly include emotions in their theoretical definitions, the neural mechanisms reveal the rich emotions in those constructs. To elucidate the neural mechanisms of the constructs, I organized the findings by four different leadership approaches (i.e., a pattern of leadership behaviors; Waldman & Balthazard, 2015): charismatic, transformational, destructive, and culturally responsive school leadership. Organizing the findings in this way is by no means perfect, as the constructs under each educational leadership approach are not mutually exclusive. For instance, the constructs of trust and organizational justice could be organized into all leadership approaches. It is also important to note that the reviewed studies did not reveal the neural mechanisms of the constructs of all educational leadership approaches (e.g., instructional, distributed, and teacher leadership), because no empirical neuroscience studies were found that directly examined the constructs related to these leadership approaches. Nevertheless, considering that educational leadership can be conceptualized in multiple, oftentimes interconnected, leadership approaches (Wang, 2018), here I detail the neural mechanisms of the core constructs relevant to each of the four leadership approaches.

Charismatic Leadership

Charismatic leadership is one of the leadership approaches that has garnered a great amount of interest in leadership research (Dinh et al., 2014; Meuser et al., 2016). Charismatic leadership draws heavily on leaders' charisma. The word "charisma", originated from Greek, means "divine gift" (Weber, 1947). The neuroscience findings accentuate the role of envisioning the future and emotions in charismatic leadership. First, when people envision the future, the brain's default-mode network (DMN) is activated, including the vmPFC—part of the brain regions that process emotions (Buckner et al., 2008). Further, the brain regions, activated while envisioning the future are the same regions activated while remembering the past (Schacter, Addis, & Buckner, 2007). In addition to the emotions evoked by envisioning the future and remembering the past, another emotional side of charismatic leadership is supported by the correlation between charismatic leadership and a leader's positive emotional expression which is contagious and influence the followers' emotions (Bono & Ilies, 2006).

Second, to inspire followers to envision the future, charismatic leaders develop a bold, socialized vision, and communicate it effectively. A charismatic leader's visionary communication mediates the relationship between the leader's narcissism personality and charismatic leadership: the narcissism personality prompts a charismatic leader to craft a bold vision that galvanizes followers (Galvin, Waldman, & Balthazard, 2010). Two studies in organizational neuroscience explored further on the socialized and personal-oriented visionary communication. On the leaders' end, the leaders' brain activity in the right frontal cortex was more strongly correlated to the leaders' socialized visionary communication (e.g., focusing on we, empowerment, and the roles of the team and communities) than the personal-oriented one (e.g., focusing on me, exploiting others, and not acknowledging the roles of the team; Waldman, Balthazard, & Peterson, 2011). On the followers' end, the followers' brains process the leaders' vision differently, depending on the follower-leader shared social identity—the socially construed identity based on ethnic, religious, socioeconomic, and other social categorizations (Molenberghs, Prochilo, Steffens, Zacher, & Haslam, 2015). When the leader shares the followers' social identity, the followers process the leader's inspirational vision by recruiting the brain regions processing semantic information; however, when the leader does not share the followers' social identity, the followers' brains dismiss the leader's inspirational vision as the non-inspirational one. This finding indicates that the followers do not respond to the leaders' vision in a universal, undifferentiated approach. The leaders' bold, socialized vision would be in vain if they fail to share their followers' social identity. In sum, a charismatic leader uses the bold, socialized vision to evoke the emotions in people by envisioning the future and remembering the past. The charismatic leader also skillfully develops a shared social identity so that the leader's inspirational vision is well-received by the followers, instead of being dismissed as the non-inspirational one.

Transformational Leadership

Transformational leadership has four core theoretical dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration (Bass, 1998). Like charismatic leadership, transformational leadership also has an emotional side. Transformational leaders are skillful in expressing positive emotions (e.g., being optimistic and hopeful) and recognizing the emotions of others (Rubin, Munz, & Bommer, 2005). First, the leaders who express more positive emotions have greater brain activity in the left prefrontal cortex (a brain region associated with resilience and sensemaking skills; Peterson, Balthazard, Waldman, & Thatcher, 2008). Second, the association between recognizing the emotions of others and transformational leadership is moderated by the personality trait of extraversion which has a unique brain structure: The extraverts tend to have larger volume of the vmPFC, a brain region involved in processing emotions (DeYoung et al., 2010). In addition to extroversion, the personality trait of agreeableness is another predictor of transformational leadership (Judge & Bono, 2000). The agreeableness personality has a unique brain structure as well. Agreeableness covariates with the volume of two brain regions: (1) the superior temporal sulcus that not only supports emotional contagion which is part of the psychological process of empathy (Singer et al., 2004), but also has intense activity when processing organizational injustice, particularly procedural injustice (Dulebohn, Conlon, Sarinopoulos, Davison, & McNamara, 2009); and (2) the posterior cingulate cortex, as part of the DMN, which supports mentalizing, envisioning the future, and remembering the past (Buckner et al., 2008). The neural substrates of the agreeableness personality are consistent with the psychology literature denoting the prosocial behaviors of agreeable people, including empathizing with others, understanding others' intentions and mental states, as well as helping others (Graziano, Habashi, Sheese, & Tobin, 2007). Taken together, although extraversion and agreeableness are the personality traits associated with transformational leadership, their neural substrates indicate the rich emotional experience of transformational leaders. This finding lends neuroscience support to the positive association between transformational leaders and their emotional intelligence (Barbuto & Burbach, 2006).

Destructive Leadership

In educational leadership literature, the wide spectrum of leadership behaviors mostly focuses on the behaviors that yield positive consequences such as inspiring people, transforming organizations, and promoting teaching and learning. Yet the attention to the leadership behaviors that are destructive and exacerbate organizational woes has been largely muted. The pattern of volitional, deviant, and toxic behaviors by a leader is considered as destructive leadership (Krasikova, Green, & Lebreton, 2013). Destructive leaders employ intimidating and retaliation tactics "to pursue goals that contravene the legitimate interests of the organization" (Krasikova et al., 2013, p. 1310). The neuroscience literature sheds much light on destructive leadership behaviors.

Destructive leadership appears to be associated with the so-called Dark Triad personality (Paulhus & Williams, 2002): three socially aversive yet non-pathological personality traits of narcissism, psychopathy, and Machiavellianism. First, narcissists, as noted earlier, engineer a bold vision to motivate followers (Galvin et al., 2010). Compared to charismatic leaders' bold, socialized vision, the destructive leaders' vision focuses more on the leaders' personal gain, instead of the interest of the followers and organization. This explains why destructive leadership has a theoretical component of *personalized* charismatic leadership (Krasikova et al., 2013).

Second, the psychopathic trait is associated with the decreased activity in the vmPFC and amygdala. The decreased activation in the vmPFC explains why the psychopaths are incapable to empathize with others, and are “blind” to the fear expressed by others (Decety, Chen, Harenski, & Kiehl, 2013). Moreover, the decreased activation in the amygdala explains the psychopaths’ decreased response to fear-provoking stimuli (Blair, 2010). It is thus the psychopaths’ deficiency in empathizing with others and recognizing others’ fear that prompts them to callously exploit others with emotional detachment.

Third, the Machiavellianism, manifested by the social behaviors of manipulating others for personal, self-serving goals (Wilson, Near, & Miller, 1998), is undergirded by the trade-off of two psychological processes of empathy: emotional contagion and mentalizing (Bagozzi et al., 2013). Bagozzi et al.’s neuroimaging study found that in comparison with low Machiavellians, high Machiavellians exhibit relatively greater emotional sharing with others (i.e., emotional contagion) but lower capability of mentalizing. Further, high Machiavellians are more likely to violate trust and to be dishonest, exhibiting the behaviors of breaking promises, cheating, stealing, and lying (Fehr, Samsom, & Paulhus, 1992). Being dishonest engages the brain region of the amygdala; more importantly, the amygdala sensitivity to dishonesty is like a slippery slope: its sensitivity to dishonesty on a present decision relative to the previous one predicts the magnitude of escalation of self-serving dishonesty on the next decision (Garrett, Lazzaro, Ariely, & Sharot, 2016). In an organization, a dishonest leader is likely to violate the followers’ trust which entails honesty, leading to the followers’ distrust in the leader (Krasikova et al., 2013; Tschannen-Moran & Hoy, 2000).

Distrust is associated with greater activity in the brain regions of the insular cortex (a neural correlate of disgust and stigmatizing others) and amygdala (a neural correlate of fear and perceiving threat; Dimoka, 2010; Wicker et al., 2003). By contrast, trust is associated with greater activation in the brain regions of the ventral tegmental area and caudate nucleus, which are associated with anticipating positive rewards, evaluating the fairness of a social partner's decision, and repaying the social partners with trust (Dimoka, 2010; Krueger, McCabe, Moll, Kriegeskorte, & Zahn, 2007). Further, trust also has its neural correlates in the anterior paracingulate cortex, a brain region activates when inferring another person’s benevolent intentions. Thus, distrust is associated with negative emotions of disgust and fear, whereas trust is associated with the brain’s reward and social cognition regions. To that end, the neuroimaging evidence of the different neural underpinnings of trust and distrust provides theoretical clarity to the two key constructs in educational leadership.

Destructive leaders become angry and aggressive, when their self-serving goals are blocked by the followers (Krasikova et al., 2013). In an organization led by a destructive leader, the followers blocking the leaders’ self-serving goals are perceived by the leader as a threat, thereby activating the leader’s amygdala which then produces a visceral, negative emotion of anger, as well as aggressive, impulsive behaviors to punish, retaliate, and inflict harm on those who block the leader’s self-serving goals (Nelson & Trainor, 2007). To do so, the destructive leaders resort to intimidation and retaliation tactics, including hostile verbal and nonverbal bullying, threatening, coercing, playing favorites, belittling and disempowering followers, restricting followers’ intellectual independence, cultivating dependence on the leader, and many other destructive behaviors documented in a study concerning the school principals' mistreatment on teachers (Blasé & Blasé, 2002). On the end of followers, to process the destructive leader's anger, the followers engage the orbitofrontal cortex and anterior cingulate cortex, the brain regions supporting the function of identifying social violations (Fusar-Poli et al., 2009). Facing the leader's impulsive, aggressive behaviors, the followers' brain region amygdala is also active, as the amygdala is the brain region perceiving fear-provoking stimuli. As a result, the anger, aggression, and impulsivity on both ends of the leader and followers provoke one another, creating a vicious cycle of toxic, negative emotions in the organization.

Culturally Responsive School leadership

Culturally responsive school leadership centers around the leader's behaviors engaging in inclusion, equity, advocacy, and social justice in schools. Specifically, it encompasses four dimensions: critically self-reflecting on leadership behaviors, developing culturally responsive teachers, promoting culturally inclusive school environment, and engaging students, parents, and indigenous contexts (Khalifa, Gooden, & Davis, 2016). Although no neuroscience studies on culturally responsive school leadership have been found, many neuroscience studies have already uncovered the neural mechanisms of relevant constructs, including social identity, justice, and empathy.

First, social identity prompts us to, often implicitly and unconsciously, favor in-groups and discriminate out-groups (Amodio, 2014). The in-group vs. out-group boundaries are drawn based on socially construed categorizations, including ethnicity, gender, nationality, religion, disability, sexual orientation, socioeconomic status, political party affiliations, among others. We are prone to draw in-group vs. out-group (us vs.

them) boundaries; once it is drawn, we are likely to think those in our in-groups are smarter, more moral, and more just than the members in out-groups (Culotta, 2012; Ellemers, 2012). This *unconscious* bias towards in-groups—such as the bias based on race, gender, and social status—takes less than one-tenth of a second (100 milliseconds), so short a time that people are unaware of the bias (Nosek, Hawkins, & Frazier, 2011). In comparison, it takes 500 milliseconds or more to activate the PFC, particularly the dlPFC, which helps us to be aware of our bias and dampen the brain activity in the amygdala, thereby regulating the bias (Knutson et al., 2006). Further, as noted earlier, when followers do not perceive that their leader shares their social identity, the leader's inspirational vision is dismissed as the non-inspirational one in the followers' brain (Molenberghs et al., 2015). Neuroimaging evidence suggests our social identity is associated with the brain activity in the amygdala and insular cortex (the neural substrates for distrust, disgust, and perceiving threat; Dimoka, 2010; Rilling, Dagenaisa, Goldsmith, Glenn, & Pagnoni, 2008). The activity in these brain regions is more intense as we interact with people who do not share our social identity, including showing less empathy towards out-groups, and having a propensity to stigmatize, stereotype, and dehumanize out-groups (Culotta, 2012; Ellemers, 2012; Molenberghs et al., 2015). More importantly, the amygdala sensitivity to race is not present in childhood but emerges over adolescence; thus, the "heightened amygdala response to African American faces may reflect learned cultural knowledge, such as implicit and explicit stereotypes" (Telzer, Humphreys, Shapiro, & Tottenham, 2013, p. 241). The good news is that the neural mechanisms of social identity are malleable (Blair, 2002). How our brain responds to out-group race faces is influenced by our inter-racial interactions and racially diverse social networks, which dampens the amygdala activation (Telzer et al., 2013). To that end, culturally responsive school leadership is also "identity leadership" (Haslam, Reicher & Platow, 2011, p. 197): engineering a collective social identity, rather than pitting "us" against "them" in schools and communities; building an organizational structure and developing policies that facilitate inter-group interactions and cooperation, and ultimately creating a wide-ranging concept of "us" in schools and communities.

Second, it is important that culturally responsive school leaders ensure justice in schools. Justice refers to "a system of normative rules and principles concerning the impartial allocation of rights, responsibilities, and resources" (Decety & Yoder, 2017, p. 7). The neuroscience findings suggest humans have a justice motivation: the tendency to prefer justice in their own life (self-oriented justice) and the lives of others (other-oriented justice, Decety & Yoder, 2017). Regarding self-oriented justice, as noted earlier, when we are treated fairly, our dopaminergic system is activated (Tabibnia et al., 2008), in particular the same brain regions that are activated when we eat chocolate; thus, "fairness tastes like chocolate" (Lieberman, 2013, p. 73). Regarding other-oriented justice, when we see others being treated unjustly, our natural preference for justice is violated, triggering moral outrage which motivates us to right the wrong and uphold justice (Decety & Yoder, 2017). As a result, justice motivation is important in culturally responsive school leadership, because it motivates the leaders to initiate organizational changes that rid injustices. In organizational contexts, there is compelling neuroimaging evidence that differentiates two core dimensions of organizational injustice (Colquitt, Conlon, Wesson, Porter, & Ng, 2001): procedural and distributive injustice. Procedural injustice—the unfair processes of allocating resources (e.g., making hiring decisions based on nepotism rather than merit)—evokes greater activation in the brain regions related to social cognition, such as the ventrolateral PFC and superior temporal sulcus; whereas distributive injustice—the unfair outcomes or resources that individuals receive—evokes greater activation in the brain regions processing negative emotions, such as the anterior cingulate cortex, anterior insula, and dlPFC (Dulebohn et al., 2009). These findings thus provide theoretical clarity that procedural injustice is more about social cognition, whereas distributive injustice is rooted in processing negative emotions (Dimoka, 2010; Dulebohn et al., 2009). Moreover, when we have to tolerate injustices, there is increased brain activity in the right ventrolateral PFC, but decreased activity in the anterior insula, which indicates that we suppress the negative emotions when we tolerate injustices in organizations (Tabibnia et al., 2008).

Third, it takes empathy for culturally responsive school leaders to go beyond the emancipatory leadership practices of resistance, and to advocate for the students, teachers, and communities they serve. The word empathy came from the German word Einfühlung, which means “feeling into” (Liberman, 2015). Empathy comprises three psychological processes—emotional contagion, mentalizing, and empathic motivation—that recruit disparate brain systems. First, emotional contagion refers to the psychological process in which perceivers share the targets’ emotional states, creating the emotional resonance (Gallese, Keysers, & Rizzolatti, 2004). When people are emotionally resonant, their brains have similar activities (Lamm & Majdandžić, 2014; Singer et al., 2004). It takes pains to empathize, because the same brain regions (the anterior mid-cingulate cortex and anterior insula) are activated when we experience physical pain and empathize with the pain of others (Singer et al., 2004). The second psychological process of empathy is mentalizing, which recruits the brain regions (the temporoparietal junction, temporal ole, precuneus, posterior cingulate cortex, and medial PFC; Zaki & Ochsner, 2012) that support “self-projection”: the perceivers’ ability to put themselves in others’ shoes (Buckner & Carroll, 2007). The third psychological process of empathy is empathic motivation—the process in which the perceivers express motivation to reduce the targets’ sufferings through generosity, altruistic behaviors, and calming body contact/language (e.g., close-up eye-contact, touching, stroking, putting an arm around others shoulders, and bodily synchronizations; Decety, Bartal, Uzefovsky, & Knafo-Noam, 2016; Zaki & Ochsner, 2012). To be empathically motivated, the septal area in our brain takes the converging inputs from other brain regions involved in empathy and converts them to the empathic motivation to help. Since the septal area is in the brain’s reward system, we feel gratified (the warm glow) when we are motivated to express our empathy to reduce other’s sufferings (Lieberman, 2015).

Empathy, however, has a sinister side: humans tend to show empathy discriminately based on the social identity (Haslam et al., 2011; Lamm & Majdandžić, 2014). There is substantial, consistent neuroscience evidence denoting that humans have reduced neural responses to the pain being inflicted on ethnic out-group members (Sheng & Han, 2012). Empathy thus has a boundary shaped by social identity: we tend to empathize with and being altruistic towards those who are members of our in-groups (Ellemers, 2012). The bounded empathy and parochial altruism have been linked to the role of oxytocin—the neurotransmitter associated with social bonding, trust, and generosity (De Dreu et al., 2010). Accordingly, the telling neuroscience evidence suggests that a culturally responsive school leader needs to be skillful in crafting an collective social identity so that the negative emotions of fear and disgust towards the out-groups are reduced, being sensitive to organizational injustices so that moral outrage motivates people to rid injustices, and empathizing with the people in the schools and communities in order to "create school contexts and curriculum that respond effectively to the educational, social, political, and cultural needs of students" (Khalifa et al. 2016, p. 1278). All these leadership behaviors, as noted above, involve in the emotions of fear, disgust, moral outrage, and empathy.

Discussion

This review study provides an up-to-date synthesis of the empirical literature where the knowledge of neuroscience and educational leadership converge. It is the author's abiding hope that the synthesized neuroscience findings here will stimulate further theoretical and methodological insights in educational leadership, as well as integrate neuroscientific work in school leadership preparation and professional development.

Theoretical Implications

The theoretical implications of this study are twofold. First, the findings of the neural underpinnings of many constructs accentuate the role of emotions in educational leadership. All four educational leadership approaches discussed in this study (charismatic, transformational, destructive, and culturally responsive school leadership) tap into emotions. Charismatic leaders appeal to people's emotions, express their own emotions, and inspire people by evoking their followers' emotions through envisioning the future and remembering the past. Transformational leaders express their positive emotions and mentalize the followers' emotions. Destructive leaders manipulate the followers by arousing people's fear and anger. Culturally responsive school leaders empathize with the followers, channel moral outrage as the motivator of change, and regulate negative emotions of fear and disgust through building a collective social identity and ensure organizational justice.

Emotions are the common thread weaving through all four leadership approaches. In everyday life, emotions and feelings (e.g., feel happy and nervous) are used interchangeably. However, in neuroscience, emotions consist of three components: (1) a physiological reaction (e.g., the racing heart, spiking blood pressure, dry mouth, and sweating palms) to a stimulus, (2) a behavioral response (e.g., fret when we are anxious), and (3) a feeling (e.g., being euphoric or frightened; Gazzaniga et al., 2013; Glimcher & Fehr, 2014). The emotions are important in educational leadership in at least two ways. The emotions are important in educational leadership in at least two ways. First, educational leaders should not be stoic human beings devoid of emotions. Rather, they need to be emotionally authentic by expressing positive emotions in order to build a positive-emotionally charged organizational culture. Leaders' expression of positive emotions, which activate the same brain regions of charismatic leaders and transformational leaders, provides the consistent evidence between the neuroscience findings and the conceptual overlap between transformational and charismatic leadership (Bono & Ilies, 2006; Rubin et al., 2005). Leaders' positive emotions are also contagious (Johnson, 2008); thus, positive emotions in a school trigger more positive emotions not only by external events or stimuli (what people see and experience at the moment), but also by remembering the past and envisioning the future. Second, the emotions influence school leaders' decision making. The saying "Do not let emotions cloud your judgment" does not hold true under all circumstances, as noted previously (Evers & Lakomski, 2015; Lakomski, 2016; Lakomski & Evers, 2010, 2012, 2017). The DMN-TPN antagonistic relationship uncovered in Bagozzi et al.'s (2013) study offers further evidence that it is erroneous to exclude certain emotions from decision making. More importantly, the DMN-TPN trade-off explains why we do not see hot-blooded compassion (associated with the DMN activation) and cold-blooded calculation (associated with the TPN activation) simultaneously in the same person. Some emotions (e.g., empathy and compassion) play a competing role against rational, analytical thinking in making moral decisions (Greene et al., 2001; Bagozzi et al., 2013). These findings prompt us to rethink that the *overreliance* of data-driven decision making and school accountability system might create an instrumental environment for school leaders to make immoral decisions. Until recently, emotions have often been overlooked in educational leadership, thereby warranting intensified scholarly efforts. The future inquiry is thus encouraged to examine how to strike a balance, and where school leaders draw the line to lean more on emotions or data in their decision making.

In addition to accentuating the role of emotions, the findings of this study have the potential of bringing theoretical clarity and theoretical cohesion to the field of educational leadership. First, neuroscientific work may produce an alternative, granular view of the theoretical constructs that underpin educational leadership. For instance, the findings clarify from the neural perspectives the differences between trust and distrust (Dimoka, 2010), as well as procedural and distributive justice (Dulebohn, Conlon, Sarinopoulos, Davison, & McNamara, 2009). The findings also extend the existing theories of educational leadership approaches to charismatic leadership and destructive leadership, the two leadership approaches that have been largely overlooked in the field of educational leadership. Charisma does not appear to be an elusive construct if examined through how followers' emotions are aroused by envisioning the future and remembering the past, and how the leaders' bold, socialized vision is perceived through the shared social identity between the leaders and followers. Destructive leadership, in particular, might provide the theoretical groundings to the research on low-performing schools, teacher burnout, and teacher retention. Further, the uncovered neural mechanisms of the constructs relevant to human behavior, in particular social behavior, may hold the potential of bringing some coherence to the theoretical groundings of the field of educational leadership. For instance, the overlapped neural mechanisms between empathizing with others and making moral decisions (Pascual et al., 2013) suggest the potential of bringing theoretical cohesion to the constructs and theories on emotions, decision making, and moral leadership (Churchland, 2012). Moreover, the neural correlates of the core constructs pertinent to educational leadership point to two sets of brain regions processing emotions: (1) the alarm system (e.g., the amygdala, anterior insula, dorsal anterior cingulate cortex, and periaqueductal gray) that detects and responds to danger or threat, thereby arousing the emotion of fear and the resultant organizational behaviors; and (2) the reward system (e.g., the vmPFC, ventral striatum, and septal area) that makes us feel gratified in social interactions and motivates us to care for others (Eisenberger & Cole, 2012). These two sets of emotion-processing brain regions might help us refine and bring synergies to the constructs and theories that anchor human behaviors in organizational contexts by integrating emotions, psychological processes, and leadership behaviors.

Further, with the rise of social justice leadership and culturally responsive leadership as the core theories in educational leadership (Khalifa et al., 2016; Wang, 2018), the findings from neuroscience might be able to propel the theory development in educational leadership. First, there has been a stream of neuroscience studies examining the neural mechanisms associated with social justice, fairness, and poverty (see Nam, Jost, & Feldman, 2017, for the special issue of the Neurobiology of Fairness and Social Justice in the journal *Social Justice Research*). For instance, the neuroimaging evidence suggests that people living in poverty have diminished neural responses to positive experience and reward, possibly explaining the link between poverty and emotional dysregulation disorder (e.g., excessive anxiety, fear, and anger; Silverman, Muennig, Liu, Rosen, Goldstein, 2009). Second, cultural neuroscience is a field that intersects neuroscience, genetics, and cross-cultural psychology to study how cultural values and practices shape human brain structure and function, and vice versa (Chiao, 2009). For instance, Park and Huang (2010) asserted that sustained cultural exposure had a lasting imprint on brain functions and behavioral responses, and reported neuroimaging evidence suggesting the differences in brain functions in visual and perceptual processing between those exposed to the East Asian collectivist culture and those exposed to the Western individualistic culture. Further, a recent study of immigrants reported that their brain activity began to change as early as the first two months of living in a new culture (Chen, Wagner, Kelley, & Heatherton, 2015). The insights gleaned from cultural neuroscience may contribute to the theory development of culturally responsive school leadership by enriching our understanding of how the cognitions, perceptions, and behaviors of students, teachers, parents, and communities from different cultures are shaped by their culturally and socially situated organizational contexts.

Methodological Implications

The neuroscience methods add to the methodological repertoire of educational leadership research. The neuroscience literature reviewed in this study employs an array of analytical approaches that are novel to the field of educational leadership, including the functional magnetic resonance imaging (fMRI) of brain anatomical structure and functions, using quantitative electroencephalogram (qEEG) to detect electrical activity at the skull's surface, and the hormonal analysis of physiologically signaling chemicals related to social behaviors.

First, fMRI uses the oxygenated blood flowing to active brain regions as the proxy for measuring neuron activity, producing measurements of brain structure and functions from deep inside the brain (Soares et al., 2016). The fMRI has been increasingly used to examine brain activity in psychological processes (Cacioppo, Berntson, & Nusbaum, 2008), adding theoretical clarity to some key constructs in educational leadership. For instance, in educational leadership, trust has been measured by five dimensions of benevolence, reliability, competence, honesty, and openness (Tschannen-Moran & Hoy, 2000). Using fMRI, Dimoka's (2010) study showed that trust and distrust are distinct constructs, not because trust activates certain brain regions and distrust de-activates the same brain regions. Rather, trust and distrust engage different brain regions and have different neurological processes: trust is associated with the greater activity in the brain regions processing reward and inferring social partner's intentions, but lower activity in the brain region calculating uncertainty; by contrast, distrust is associated with intense activity in the brain regions processing negative emotions such as fear and disgust. Another example is the study of moral decision making. Using fMRI, Greene et al. (2001) scanned the participants' brains when they contemplated moral dilemmas such as the famed trolley problem of choosing between killing one person and five people, and found that making moral decisions engages the brain regions processing emotions, which suggests the emotional engagement when people make moral decisions.

Second, unlike fMRI which produces measurements from deep inside the brain, qEEG measures electrical activity from the surface of the scalp and skull of the cerebral cortex (Niedermeyer & Silva, 1995). In leadership research, qEEG has been used to differentiate the brain activity between charismatic and non-charismatic leaders (Waldman, Balthazard, & Peterson, 2011), as well as transformational and non-transformational leaders (Balthazard, Waldman, Thatcher, & Hannah, 2012). Further, qEEG was used to measure leaders' psychological capital (Peterson et al., 2008), and leaders' self-complexity (the leaders' self-concept which drives information processing and self-regulation) when the participants made adaptive decisions in order to adjust their thoughts and behaviors to enact appropriate responses to ill-defined, evolving situations (Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2015).

Third, hormonal analysis measures the modulation of physiological signaling chemicals in human body. The hormone levels can be analyzed from blood and/or saliva samples. Scholars have conducted hormonal analysis of an array of hormones that are related to leadership and organizational behaviors, including oxytocin, testosterone, and cortisol. First, the oxytocin level, analyzed from blood samples, was found to be associated with trust, empathy, and generosity (Barraza & Zak, 2009). Second, the testosterone level was examined at the team level, and was found that the mismatch between the individuals' testosterone level and the position status in the group is associated with collective efficacy of the group (Zyphur, Narayanan, Koh, & Koh, 2009). That is, the greater the mismatch between the group members' testosterone levels and their position status in the group (i.e., the more negative the within-group correlation among testosterone and status), the lower the group's collective efficacy. This is because the level of testosterone has been found to be associated with motivation for power and social dominance (Sellers et al., 2007). When testosterone and social status are mismatched in a team, the low-testosterone team members are uncomfortable in high-status positions, thereby becoming emotionally disturbed and cognitively distracted; by contrast, the high-testosterone team members with low position status tend to have less positive emotions and depleted cognitive resources (Josephs, Sellers, Newman, & Mehta, 2006). Third, cortisol, as a stress hormone, has already been analyzed in some organizational studies (Becker & Menges, 2013). For example, the people, who believed they had little control at work, had heightened levels of cortisol, whereas those with high control at work did not show such a physiological reaction (Fox, Dwyer, & Ganster, 1993). Considering power being about having control, Fox et al.'s study thus lends physiological support to the importance of leaders empowering followers.

The above neuroscience methods (fMRI, qEEG, and hormonal analysis) are not competing but supplementary to the existing research methods of educational leadership. The neuroscience methods are particularly helpful to study the unconscious, implicit attitude, perceptions, and prejudice that research participants are unaware of.

Accordingly, such methods may generate data that are less prone to social desirability concerns than self-report data (Taber & Young, 2013). Yet like all research methods, the neuroscience methods introduced above have limitations as well. For instance, fMRI does not suggest causation. We cannot scan two leaders' brain and tell which person is the better leader. Another cautionary note for leadership researchers is that the measurement of brain activity alone is *insufficient* to differentiate leadership traits, leadership behaviors, or leadership approaches, given the adaptive nature of human behavior in social processes in organizations (Lee et al., 2012). To that end, to apply neuroscience to educational leadership, we must shift the focus from studying the activation of certain brain regions to examining leadership behaviors from a socially situated view. Becker and Menges (2013) thus recommended that leadership researchers to simultaneously employ both traditional and neuroscience methods (e.g., Bagozzi et al., 2013; Waldman et al., 2011). Such a supplementary methodological approach has already provided an alternative view in leadership research. For instance, Hannah et al.'s (2013) study indicated that both of the qEEG-based index and the psychometric-based measure of leader self-complexity accounted for unique variance in leaders' adaptive decision making.

Practical Implications

What are the implications of this study's findings for school leadership preparation and training? First, the role of emotions weaving through all four leadership approaches warrants the training of school leaders' emotions. The leaders need to be trained to recognize, express, and regulate their own emotions, as well as recognize others' emotions. Further, the findings of this study present the potential of applying neuroscience to school leadership preparation and training. Imagine we could gain an understanding in real time the school leaders' brain activity patterns and infer psychological and decision-making processes. Since the neural pathways in our brain are malleable, it is possible to apply insights from neuroscience to shape behavioral interventions through integrating brain and behavior levels of analysis in school leadership preparation and professional development. A recent example is to capitalize on the malleability of human brain to reduce people's prejudice towards others and enhance their capacity to empathize (Farmer & Maister, 2017; Singer & Klimecki, 2014). The neurological measurements, in particular the relatively affordable and non-invasive qEEG, could be used to gauge the brain activity of participants in school leadership preparation programs and continual leadership training. There are already precedents for applying neuroscience to leadership training. The qEEG has already been used to measure the leaders' self-complexity as military leaders engaged in analyzing and problem-solving in complex combat scenarios (Hannah et al., 2015). Similarly, the qEEG can be used to gauge school leaders' brain activity as they engage in the situational analysis and problem-solving of the complex cases published in the *Journal of Cases in Educational Leadership*. In addition to using qEEG to measure leaders individually, it has been used in team settings where business leaders' brain activity was assessed to examine team engagement and the emergence of leadership as the team engaged in solving a business case (Waldman et al., 2013). Grounded in the neural mechanisms of constructs and psychological processes (e.g., self-complexity, morality, justice sensitivity, empathy, trust, and distrust), it is also possible to longitudinally measure the brain activity related to those constructs and psychological processes to evaluate the effectiveness of leadership training over time.

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